# Citizen-volunteer and professional monitoring to identify fecal sources of contamination in southwestern Puerto Rico

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## Project summary

High concentrations of nutrients, fecal microorganisms, and sediments in surface waters can be a public health threat and can impact fringing coral reefs in Guánica Bay in southwestern Puerto Rico. Yet, the main factors and sources contributing to water quality degradation (e.g. the relative contribution from agriculture, urban, and suburban sources) are unknown. There is a need to create awareness and to develop mechanisms to improve surface and coastal water quality. In this project we are using 4-H program students as citizen volunteers and professional monitoring to characterize the surface water-quality status within the drainage channel from the Lajas Valley watershed and the lower reaches of Río Loco (drainage of Guánica watershed) during hydrologic low- and high-flows. Twenty-four stations have been identified within the area, each having a specific geographic delineation that will have land cover types, land-use classes, and point-source identification. Samples will be analyzed for nutrients (nitrogen and phosphorus), suspended sediments, *Enterococcus* (as fecal indicator of contamination) and heavy metal concentrations (as indicators of anthropogenic sources). We will quantify the presence of *Bacteroidales (H183)* marker, as a specific indicator of human fecal contamination. A GIS-based spatial database is being created that includes land-use, point- and non-point sources of pollution that will aid in pinpointing the sources of contamination to the drainage basins and eventually to Guánica Bay. Citizen volunteers have been trained through an eight-hour theoretical and practical workshop and they have initiated sampling. We expect to provide tools that will increase public and community awareness of sanitation issues in the lower Guánica watershed through education, training, and participation in assessments of water quality and wastewater management infrastructure.

## Project objectives

- Carry out contaminant (nutrient, metals and fecal indicators of contamination) monitoring
- Use GIS tools to identify point and non-point sources of contaminants
- Use monitoring results in combination with GIS to link contaminants to specific sources
- Educate citizen-volunteer groups in order to improve public awareness and provide potential solutions

## Project workshop and volunteer training

**(19 and 20 July 2014, AES Lajas)**

- Five hours of theory and three hours of supervised practice
- 13 students plus their mentors completed the training
- UPRM support staff participated in the training
- All participants were given a Certificate of Acomplishment
- Topics covered
  1. Basic concepts on watershed management
  2. Description of the project; overview of Valle de Lajas and Guánica watersheds
  3. Water quality status of rivers, streams and lakes in Puerto Rico Monitoring
  4. Identification of sources of contamination, watershed deliniation
  5. Detailed explanation and description of sampling protocols, instrumentation and documentation
- Pre- and post-workshop assessment showed a 71% improvement (36 to 72%) in knowledge and skills related to learning objectives
- See presentations online at: http://www.waterqualitypr.com/documentos.html

## Project scientific group

- Luis Pérez-Alegría – UPRM Professor; hydrology and watershed modeling
- Gustavo A. Martínez – UPRM Research Professor; Soil and water chemistry
- Dave Bachoon – GCSU Professor; Microbiology, microbial source tracking
- Glorisell Negrón – UPRM Extension Professor, Environmental health and education specialist
- David Sotomayor-Ramírez - UPRM Research Professor; Project leader, Soil and water chemistry
- Bill Fisher – USEPA project manager

## Project support personnel

- Paloma Rodríguez – MSc Soils, graduate student
- Cristina López – MSc Soils, graduate student
- Armando Román – Microbiology undergraduate student
- Hector Torres – Field Research Technician
- Rosario Gaud - Laboratory Research Technician

## Citizen monitoring (4-H students) and their mentors

Agronomist and UPRM Extension Professor, Isbeth Irizarry, Guánica

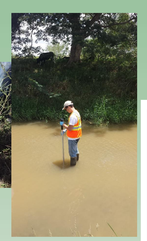
- Group #1 - Katiushka Berrocales, Juan Carlos Garcia, Christopher Rivera (Aurea E. Quiles HS, Guánica)
- Group #2 - Carlos Vega, Adriana Rosado, Kevin Santiago (Aurea E. Quiles HS, Guánica)
- Group #3 - Marielis Nivar, Damaris Vega, Alexander Casillas (Aurea E. Quiles HS, Guánica)

Agronomist and UPRM Extension Professor, Anibal Ruiz, Lajas

- Group #4 – Yaneris Torres Burgos (Lysander Borrero Terry HS), Zulimar Nazario Joyce Acosta Pardo, Nisamar Sanabria (Leonides Morales HS, Lajas)

## Volunteers during training

## Volunteers during sampling



## Sampling stations and organization

- There are a total of 24 stations
- Each volunteer group is assigned two stations
- Volunteers only sample during low-flow events
- All stations will be sampled five-times during the project
- Some stations will be sampled during storm-events by the professional group

## Water quality parameters being measured

- pH, specific conductance, temperature, dissolved oxygen (YSI Professional Plus Multi-probe®), streamflow
- Enterococcus (IDEXX Enterolert®), bacteroidales human specific marker HF183
- Total nitrogen (TKN + dissolved nitrate), dissolved nitrate, total phosphorus, metals (Ca, Mg, K, Na, Fe, Mn, Zn, Cu, Al, Cd, Cr, As), chloride, optical brighteners

## All sampling stations have a defined watershed deliniation with land-use description


| Landuse | Area | Sources | |
|---|---|---|---|
| | | Human | Animal |
| Urban and suburban | Sewage | WWTP, sewage transfer and pumping stations, WW sewage delivery infrastructure to WWTP, upstream from WWTP discharge points, downstream from WWTP discharge points | Urban animals (poultry, wildlife, dogs, cats) |
| Suburban and rural | Non-sewage | Homes/buildings with septic tanks, illegal direct discharges to drainageways, sewage delivery infrastructure to WWTP | Suburban animals (poultry, wildlife, dogs, cats), small animal (hog, goat, and poultry) production facilities |
| | | | Rural animals (poultry, wildlife, dogs, cats), dairy production facilities, small animal (hog, goat, and poultry) production facilities, large animal (horse) production facilities |

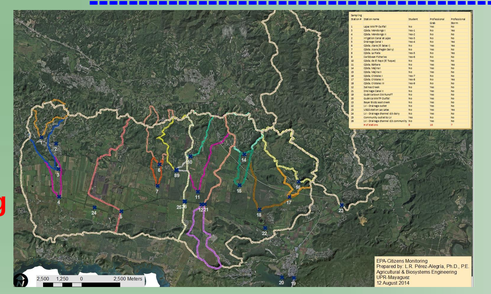
Land use (Gould et al. 2012)

- Urban - Area is not developed by at least 20% (< 80% in vegetative land-cover) or > 500 persons/km$^2$
- Sub-urban - Area has more than 80% of vegetative land-cover with > 500 persons/km$^2$
- Rural - Area has more than 80% of vegetative land-cover with < 500 persons/km$^2$

# Results

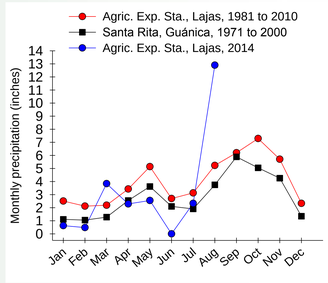
## Sampling

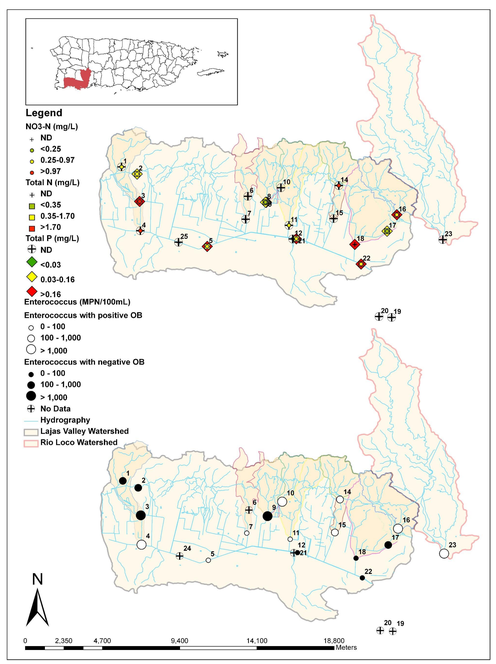
- First round of sampling from 5 Aug to 26 Aug (21 d period), one station was sampled on 3 Sep 2014.
- Stations were sampled during low-flows
- 2 stations not sampled due to lack of hydrologic flow; stations #19 and 20 within Guánica Bay have not been sampled




## Climatic conditions

- Precipitation from Jan to Jul was 12.1 in and the 30 yr normal is 21.2 in.
- Precipitation in Aug was 12.9 in and the 30 yr normal is 5.2 in; There was a 2-day 8.1 in event on 23 and 24 Aug
- Many of the stations had a very low hydrologic flows




## Land use

- All of the stations are liked to a defined sub-basin
- Land use analysis is still in progress so that linkage among nutrients, fecal contamination and land-use cannot be done, yet certain generalizations can be made:
- Station #1 is downstream the Lajas WWTP outfall, so that we expect high nutrients and fecal contaminations
- Stations #3 and #4 are within the same waterway that drains Station #1, but are downstream Lajas City. Thus we should see a strong nutrient and fecal contamination signal due to urban influence
- Station #2, located within Lajas Valley Irrigation Channel near Lajas, is considered a reference station in the sense that the channel transports water from Lago Loco and the channel should receive minimal runoff influence. Lago Loco is in the mesotrophic Trophic State Index with historical total P concentration of 36 µg/L (Martínez et al. 2005).
- Stations #24 and #5 are downstream dairy production facilities.
- Station #23 drains the upper Río Loco watershed, which has relatively limited agricultural production area, yet has a mix of urban, suburban and rural land-uses.
- Stations #16, #17, and #18 are in tandem (within the same drainage channel); Station #18 includes waters from #16 and #17 but drains a 600 acre rice-production farm.
- Station #6 is upstream and #7 is downstream a dairy production facility, but will be sampled primarily during storm events

## Nutrients

- Some of the nutrient analysis, have not been completed (ND in the legend)
- Reference Station #2 (Lajas Valley Irrigation Channel near Lajas) was “nutrient enriched”
- Station #1 (Lajas WWTP outfall) was “enriched” in $NO_3$-N; data for total P and total N is still not available
- Stations #3 and #4 (downstream Lajas City) were “nutrient impaired”; data for total P and total N is still not available for Station #4
- Stations #5, #24, and #21 (drainage channel, downstream dairy farms) were impaired in terms of total P and enriched with $NO_3$-N and total N

## Enterococci and optical brighteners (OB)

- Station #1 did not have the expected “high” Enterococcus concentrations, possibly due to chlorination; the OB signal was not detected.
- Stations #1 and #2 (Lajas WWTP outfall and Lajas Valley Irrigation Channel near Lajas) had similar Enterococci concentrations
- Stations #3 and #4 (downstream Lajas City) had very high Enterococci concentrations but only station #4 tested positive for OBs; the OB signal persisted a few kilometers downstream and then faded.
- Enterococci concentrations at the Lajas Valley drainage outlet was <100 MPN/100 mL
- Many stations draining mixed-use rural watersheds had a positive OB signal (Stations #10, #14, #15, #16 and #23) combined with high Enterococci concentrations.

**Nutrient concentrations are being interpreted in the context of suggested numeric nutrient criteria in rivers of Puerto Rico (Sotomayor-Ramirez et al. 2014)**

| Threshold | Total N | $NO_3$-N | Total P |
|---|---|---|---|
| | ----------mg/L---------- | | |
| Non-enriched | <0.35 | <0.25 | <0.030 |
| Enriched | >0.35-1.70 | >0.25-0.97 | >0.030-0.160 |
| Impaired | >1.70 | >0.97 | >0.160 |

## Acknowledgements

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- We appreciate the collaboration of USEPA Program Manager Dr. W. Fisher